Panel 2: Impact of dispersed generation on system structure including impact of enlarged community on energy development, power generation, international connections, transmission and distribution
Introduction

The important development of Distributed Energy Resources (DER) in Europe raises critical technical issues:

1. What is actually the DER situation and the regulatory environment?
2. What drivers for DER development in Europe and in France?
3. What technical and economical barriers?
4. What innovative solutions to fill in the technical gaps?
5. What R&D projects to overcome these barriers?

Outline of the presentation:

1- Analysis of the DER situation in France
2- Perspectives of grid evolution in presence of DER
3- R&D on-going collaborative projects
Analysis of the Distributed Energy Resources situation in France
1.1 DER figures and Evolution

DER definition (CIGRE WG 37-23):

• Generation less than 50 MW-100MW,
• Without planning,
• Non dispatchable,
• Usually connected to distribution power systems
### 1.1 The European situation at the end of 2005

<table>
<thead>
<tr>
<th>Country</th>
<th>Installed Capacity (GW)</th>
<th>DER (GW)</th>
<th>DER / total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>13</td>
<td>5</td>
<td>40 %</td>
</tr>
<tr>
<td>Spain</td>
<td>76</td>
<td>28</td>
<td>37 %</td>
</tr>
<tr>
<td>Germany</td>
<td>132</td>
<td>37</td>
<td>28 %</td>
</tr>
<tr>
<td>UK</td>
<td>80</td>
<td>19</td>
<td>24 %</td>
</tr>
<tr>
<td>Poland</td>
<td>32</td>
<td>5</td>
<td>16 %</td>
</tr>
<tr>
<td>France</td>
<td>116</td>
<td>5.1</td>
<td>4.5 %</td>
</tr>
</tbody>
</table>

(source: EDF R&D from EURPROG)

**Difficulties to obtain accurate figures**

- Confusion between definitions (Distributed ER, Renewables, Dispersed, etc…)
- Scope of the DSO
1.1 Current French conventional and dispersed Generation

<table>
<thead>
<tr>
<th>Maximum Power (GW)</th>
<th>Connected to RTE Network</th>
<th>Total France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>63.3</td>
<td>63.3</td>
</tr>
<tr>
<td>Fossil</td>
<td>21.8</td>
<td>25.3</td>
</tr>
<tr>
<td>Hydro</td>
<td>24</td>
<td>25.4</td>
</tr>
<tr>
<td>Other renewable</td>
<td>0.4</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>109.5</strong></td>
<td><strong>115.5</strong></td>
</tr>
</tbody>
</table>

Generation connected on distribution grid: 6 GW (capacity)

Mostly wind farms, reciprocating engine, cogeneration, small hydro
### 1.1 French dispersed Generation expected evolution

<table>
<thead>
<tr>
<th>Source</th>
<th>2005 (GW)</th>
<th>2010 (GW)</th>
<th>2020 (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>0.5</td>
<td>3 – 6</td>
<td>10 - 20</td>
</tr>
<tr>
<td>μCogeneration</td>
<td>~0</td>
<td>0</td>
<td>0 – 6</td>
</tr>
<tr>
<td>PhotoVoltaic</td>
<td>0.03</td>
<td>0.11</td>
<td>0.85</td>
</tr>
<tr>
<td>Waste</td>
<td>&lt;0.4</td>
<td>0.5</td>
<td>0.6 - 0.8</td>
</tr>
<tr>
<td>Small Hydro</td>
<td>&lt;2</td>
<td>2</td>
<td>2 – 4</td>
</tr>
</tbody>
</table>

Various previsions for wind energy
1.1 Wind Energy in France: situation

Installed Capacity (summer ’06): over 1000 MW

1500 MW expected by the end of year ‘06

Energy produced (2005): 830 GWh

Two main locations: South and extreme West (Britany)

(Source ADEME, http:suivi-eolien.com)
1.1 Wind Energy in France: evolution

Evolution of the installed wind farms capacity in France: mainly depends on incentives, policy,…
Various scenarios, reasonable expectation around 4-6 GW by 2010
1.2 Regulation

*European Directive*: target for France 21 % of RES in 2010

› in 1997: ≈ 15 % (mainly hydro power)

⇒ increase of at least 6%

⇒ incentive measures of French government

*One law (Feb. 2000), government decrees, ministerial orders*

› purchase obligation for renewable energy based plants under 12 MW (also for waste and cogeneration)

• *modification in 2005*: no fixed limit for wind power as long as they are installed in wind power development area agreed by the French administration

› attractive purchase tariffs fixed by decrees

⇒ large number of requests for grid connection of wind farms

• *in December 2004*: > 400 requests for > 3000 MW

• connection to the distribution network
1.2 Grid connection regulations in France

1995-1999 to 2003 : 5 ministerial orders

rules for grid connection of DG (< 120 MW)
distribution, transmission and island networks

Very detailed description

*Wind power => Specific rules, or adaptation, or exemption ...*

2003 : 5 ministerial orders + 2 government decrees

for network “users” => generating units

*much less detailed => complemented in DSO & TSO grid codes (published in June 2005) + contractual documents*
1.2 Grid connection regulations in France (2)

Technical limits for grid connection in France:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Range of Voltage</th>
<th>Voltage Levels</th>
<th>Power Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV</td>
<td>1 kV ≤ U ≤ 50 kV</td>
<td>(15kV, 20kV)</td>
<td>P ≤ 12 MW</td>
</tr>
<tr>
<td>LV</td>
<td>50 kV ≤ U ≤ 130 kV</td>
<td>(63 kV, 90 kV)</td>
<td>P ≤ 50 MW</td>
</tr>
<tr>
<td>LV</td>
<td>130 kV ≤ U ≤ 350 kV</td>
<td>(150 kV, 225 kV)</td>
<td>P ≤ 250 MW</td>
</tr>
<tr>
<td>LV</td>
<td>350 kV ≤ U ≤ 500 kV</td>
<td>(400 kV)</td>
<td>P &gt; 250 MW</td>
</tr>
</tbody>
</table>

MV, LV => EDF Distribution Network (up to 50kV)

HV => RTE (French Transmission System Operator)
1.3 examples of incentives

Other type of possible incentives in Europe:
- Public calls for tender (offshore wind energy in France)
- Shallow cost for grid connection (Germany)
- Obligation for electricity suppliers to supply a certain percentage of their total sales from renewable sources (UK: renewable obligation certificates)
- Tax reductions on renewable energy based plants
- Tax increase on fossils

<table>
<thead>
<tr>
<th>Country</th>
<th>Initial purchase rate for onshore wind energy (c€ / kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>8.4 decreasing over the years</td>
</tr>
<tr>
<td>Germany</td>
<td>9 decreasing over the years</td>
</tr>
<tr>
<td>Spain</td>
<td>6.3</td>
</tr>
<tr>
<td>Denmark</td>
<td>6.1</td>
</tr>
</tbody>
</table>
2

Perspectives of grid evolution in presence of DER
2.1 Technical issues

Potential issues due to connection of DER on distribution power system:

- **Grid capacity**: steady state & short-circuit Imax, voltage profile, …
- **Power quality**: harmonics, flicker, unbalance voltage, remote control signal, …
- **Grid support (ancillary services)**: reactive compensation and possible voltage control, ..
- **Protection and stability issues**: decoupling protection, withstand voltage & frequency variations (to a certain extent => fault ride through capabilities), …
- **Islanded systems**: more severe requirements, …
- **System safety**
2.2 Technical innovation options

Future Distribution «Active» networks:

• Not only increased usage of DER
• Not only sustainable management of the load
• Also, optimised usage of a flexible network topologies
  • automation
  • sensors
  • remotely controlled switches
  • intelligent protections

1- Power Systems Innovative topologies

• Examples of topologies: Meshed in Consolidated edison of New York, radial Open-Loop in EDF, etc…
2.2 Technical innovation options

2- Grid automated reconfiguration

Most of today’s operation based on local automation and manual switch

Reconfiguration = change in switches status from operator’s decision

Active networks include more automation and remotely controlled switches and offer more reconfiguration options
3- Power Systems observability

Complex networks operations implies accurate knowledge of the network in real time

This required observability could be offered by:

- Real time sensors (DER, loads, switch status…)
- Adapted Information systems
- State estimation software tools
2.2 Technical innovation options

4- Volt/Var control on Distribution

**DER connexion impact the voltage profile of loaded feeders**

**DER could be asked by DSO to contribute to voltage support:**

- Capacitor banks
- Power factor
- DER Reactive power (or voltage) controller

**Examples:** Auto-adaptative controller, transmission philosophy applied to distribution (fast automated and local primary voltage regulation, centralized and coordinated secondary voltage regulation, etc…)
2.2 Technical innovation options

5- Aggregation of dispersed generation

- Single DER: small units, non dispatchable, no contribution to ancillary services, etc...

- Mutualized several DER in order to answer technical requirements of large centralized units and play a role on electricity markets:

  Concepts of Large Scale Virtual Power Plants (European project FENIX)
2.2 Technical innovation options

6- Distribution participation to ancillary services

- Ancillary services (f/P balance, Q/V balance, restoration) are typical responsibility of TSOs

- Distribution active networks, aided by the advent of DER, offer opportunities to support TSO with typical ancillary services (Voltage support, Frequency control, restoration)

- New services opportunities: Power Quality, environmental certificates, etc…
2.2 Technical innovation options

7- Renewable and fluctuating generation

Uncertainties due to non predictable generation (wind generation, PV, hydro…)

• Better integration
• Increase profitability
• Limit wind power deviation

Opportunities of probabilistic methods for wind forecast
R&D on-going collaborative projects
3.1 IDEA

IDEA « investigating electric power distribution of the future »

Since 2000: Joint venture including LEG University Grenoble, the manufacturer Schneider Electric and the distribution utility EDF

Objectives: collaborative R&D to develop innovative solution for distribution systems integrating DER on following subjects:

- Fault detection
- Distribution grid architectures
- Optimal management of building energy systems
- PV connection and inverters
- Voltage control
- Ancillary services provided by DER
- Load management
- D-FACTS
- DER aggregation
3.2 FENIX

“Flexible Electricity Networks to Integrate the eXpected energy evolution” (FENIX, 15 M€, 2006-2009)

(EC Framework Program 6 - Sustainable Energy Systems)

Objectives:
Design, develop and validate a technical architecture and economical context for an active usage of DER on secure, reliable and economically efficient European power system

Concepts of Technical and economical aggregation LSVPP
Large Scale Virtual Power Plants

= ?
3.3 IntelliGrid international public/private Consortium

(US and international T&D utilities, public agencies, business and industries)

**OBJECTIVES:**

*Self-Healing* and *Adaptive*

*Interactive* with consumers and markets

*Optimized* to make best use of resources and equipment

*Predictive* rather than just reacting to emergencies

*Distributed* across geographical and organizational boundaries

*Integrated*, merging monitoring, control, protection, maintenance, EMS, DMS, marketing, and IT

*More Secure* from attack
3.4 European Technical Platform 7: SmartGrid

**Who:** Representative stakeholders of Electricity Value Chain

**When:** Started in 2005

**Why:** Define a vision for Europe’s Power systems by 2020, for the benefit of consumers and society from technical, economical and regulatory point of views

**Deliverables:**

- “Smartgrids Vision” published during spring 2006
  (http://www.ucte.org/pdf/News/SmartGrids_060313_%20BAT.pdf)

- Strategic Research Agenda, still to be released, that will present a roadmap to address issues identified in the Vision
Merci !

…any questions?

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